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PHYSICS.—*Some peculiar thermoelectric effects.* PAUL D. FOOTE and T. R. HARRISON, Bureau of Standards.

Benedicks[1] has recently published a description of experimental work from which the conclusion was drawn that a nonsymmetrical temperature gradient in a homogeneous wire gives rise to a galvanometrically measurable thermoelectric emf. Dr. Benedicks claims priority for this discovery and proposes the following table as a summary of the discoveries in thermoelectricity.

TABLE 1

DISCOVERIES IN THERMOELECTRICITY

	CIRCUIT	
	Heterogeneous	Homogeneous
A difference of temperatures (asymmetrical) produces an electric current	Seebeck, 1823	Benedicks, 1916
An electric current produces a difference of temperatures	Peltier, 1834	Thomson, 1856

Effects of the kind described by Benedicks have been long observed at the Geophysical Laboratory of this city, and at the Bureau of Standards especially in connection with the routine homogeneity testing of thermocouples. We have found that thermoelectric emfs may be developed by touching a hot wire to a cold wire of the same material, by crossing two wires and

[1] Compt. Rend. **163**: 751–3. 1916. Compt. Rend. **165**: 301–4. 1917. Rev. d. Metallurgie **15**: 329–32. 1918.

heating one of the wires near the junction, by drawing rapidly a hot wire over a cold wire, by joining two wires of different diameters and heating either wire near the junction, by filing a groove or a v-shaped depression in a metal rod and heating this portion of the rod, by passing a flame over a wire, and by numerous other methods. The avoiding of these parasitic emfs has made homogeneity testing a matter of some difficulty.

All of these effects are well known and were discovered from half a century to a century ago. Many of them are treated in Wiedemann's *Lehre von der Elektricität*, vol. 2. They are still of interest, however, because conclusive evidence has not been given for the causes of the various effects observed. Many reasons have been suggested and have been supported by theory and experiment, and no doubt among these many possible explanations one or more are correct, but the absolute proof of their correctness remains to be demonstrated. Thus, for example, Benedicks presents an experimental proof in which he makes use of a magnetic field. The conditions were such that very likely he observed the well-known Nernst and von Ettingshausen effect instead of the pure thermoelectric effect supposed.

The priority for the discovery of these thermoelectric effects probably belongs to Benjamin Franklin and Cavendish,[2] in 1769, or 147 years prior to Benedick's work. These investigators found that when a hot and a cold bar of the same metal were placed in contact, the cold bar became positively charged, as shown by measurements with an electroscope.

The first evidence of the existence of a current in such a circuit was obtained by Ritter[3] in 1798. In the absence of ammeters a pair of frogs was employed. The twitching of the legs showed that positive current flowed in the circuit, frog leg—cold Zn—(hot Zn–cold Zn)—frog leg.

Since 1800 numerous observers have investigated the subject. Indeed about 1850 these effects were thought by some, possibly rightly, to be more fundamental than the Seebeck effect, and it was believed that their study would lead to an interpretation

[2] FRANKLIN and CAVENDISH. Experimental Observations on Electricity, p. 403. 1769.

[3] RITTER. Gilb. Ann. 9: 292. 1801.

of the latter phenomenon. Some interesting names appear in the list of early investigators, for example, Becquerel, 1823; Nobili, 1834; Peltier, 1838; Matteuci, 1838; de Heer, 1840; Gaugain, 1862; Coulomb; Righi, 1875; Knott, 1879; Tomlinson, 1888; Stroud, 1889; etc.

Seebeck, 1826, suggested that the emf developed in a single wire on heating asymmetrically was due to a hardening and softening of different portions of the metal. He found that an emf is developed by heating the junction of two similar wires of different diameters. Magnus, 1851, after a most thorough investigation, believed the emf developed by touching a hot and a cold wire to be due to a change in hardness produced by heating. Jenkin,[4] 1862–3, performed a series of very elaborate experiments identical with those described by Benedicks in 1917. Jenkin concluded that the emf obtained by heating crossed wires was due to an oxide film acting with the metal underneath as an ordinary thermocouple, and that a sufficient temperature gradient existed through the film to account for the very large emfs observed. The magnitude of these was emphasized by the statement "to my surprise it was not until I had added resistance equal to that of 2000 miles of the Red Sea cable, that I reduced the deflections within range of my galvanometer." Jenkin proved that the effect was not chemical or electrolytic. The emf developed by touching hot and cold metal was also explained by a film of oxide. He proved that this latter effect could not be due to static electricity. He recognized that it is questionable to attribute the emfs developed with silver, gold and platinum to surface oxidations and raised the point as to whether the physical property of a metal depends not only upon its temperature but upon the time during which it has been at this temperature. Jenkin further advocated the theory of change in hardening of the two metals placed in contact.

Durham, 1872, observed that the magnitude of the emf developed on placing hot and cold metal in contact was proportional to the original temperature difference of the two metals.

[4] JENKIN. British Ass. Rep. **31**: 39–41. 1862. Idem. **32**: 173–8. 1863.

Trouton, 1886, considered the emf developed by moving a flame along a homogeneous wire. From an interesting experiment he concluded that the emf is a function of $\delta^2\theta/\delta x\,\delta\tau$ i.e., of the rate of change of the temperature gradient along the wire, and that an emf galvanometrically measurable could not be developed by a temperature gradient alone however asymmetrical. He suggests that the effect is due to either a permanent alteration in the wire, or, with some metals, to a temporary alteration which lags behind the temperature change. In this he confirms the opinion of Jenkin.

Steel,[5] 1893, under the title "A new thermoelectric phenomenon" describes several of the above mentioned effects, while Turnbull,[6] 1894, calls attention to the fact that these effects have been known for years. Turnbull suggests that the emfs are due to strain, an explanation given by LeRoux, 1867, and others.

Backhmetieff and Stambolieff,[7] 1895, heated a homogeneous wire by an electric current. The heating current was then cut off and the two ends of the wire were connected to a galvanometer while the wire cooled. "The direction of the current was almost without exception opposite to the direction of the original heating current."(!)

An interesting discussion appeared in the German technical journal *Elektro Teknische Zeitschrift* 1900–4. Egg-Sieberg "discovered" that emfs were developed on heating an iron wire by a moving flame, on touching hot to cold iron, and on heating an iron wire dipping into water—thus causing an asymmetrical temperature gradient. He concluded that since the Thomson effect was established it was quite reasonable to assume that this depended upon the steepness of the temperature gradient. Hence in a homogeneous circuit having an asymmetrical temperature gradient, a measurable emf is developed on account of the gradient coefficient of the Thomson effect.

[5] STEEL. Science, **22**: 256. 1893.
[6] TURNBULL. Science, **23**: 91–2. 1894.
[7] Journ. Russ. Phys. Chem. Soc. **27**: 1–25. 1895.

Schneider, 1904, repeated the above experiments and concluded that the effect was due to oxide. This conclusion was undoubtedly correct, especially in connection with his own work, as the resistance of the wires used increased during heating from 2 ohms to 100,000 ohms, and emfs amounting to a half volt were observed.

Hirschson, 1904, suggested that the above effect was due both to the thermoelectric action of the oxide and metal and to the fact that the oxide acted as a shunt on the iron to which it adhered. He showed that the measured potential difference may be in either direction depending upon the extent of the oxidation.

Rosing[8] investigated the emfs developed by touching hot and cold metals. He observed no emf for lead. For gold, silver, copper, iron, tin and platinum the current flows in one direction, in the reversed direction for palladium and German silver, and in either direction for aluminum depending upon the temperature. He relates the effects for these metals to the thermoelectric power relative to lead. The metals of the first group have a positive thermoelectric power, while those of the second group have a negative thermoelectric power. The thermoelectric power of aluminum is either positive or negative depending upon the temperature.

The only new suggestion which the writers are able to add to the confusion already existing is that the sign of the emfs developed upon touching hot and cold metal appears to have some relation to the sign of the Thomson effect.

The object of the present note has been two-fold. First, to call attention to the fact that the existence of many of these curious thermoelectric forces, "rediscovered" every decade, has been well recognized for over a century, and secondly, to point out that no conclusive evidence for their cause has been advanced although nearly all conceivable causes have at times been suggested.

[8] ROSING. Journ. Russ. Phys. Chem. Soc. **30**: 151. 1898.

GEOLOGY AND MINERALOGY.—*Pyrolusite from Virginia.* THOMAS L. WATSON, University of Virginia, and EDGAR T. WHERRY, Bureau of Chemistry.

PART I. GEOLOGY

Much of the manganese ore mined at Powells Fort on northeast Massanutten Mountain 6 miles north of east of Woodstock, Shenandoah County, Virginia, is crystalline in structure and of a high degree of purity. Prior to mining operations by the present company, the Stockwood Realty Corporation, the mine had been worked at different times for a long period of years, and the ore shipped was described as being remarkably clean and a high grade of soft crystallized pyrolusite. Crystals of the manganese mineral ranging up to more than a millimeter across are plentiful and are more abundant than at any other manganese mine known to the writer.

During the course of recent field investigations of Virginia manganese deposits for the State Geological Survey, collections of both the crystals and crystalline mineral were made by the writer for laboratory study. Specimens of the crystals were submitted to Doctor Edgar T. Wherry, of the Bureau of Chemistry, United States Department of Agriculture, Washington, D. C., for crystallographic study, the results of which form Part II of this paper.

In the known deposits of manganese-oxide ores of the southeast Atlantic states, the important ore minerals are usually given as psilomelane, pyrolusite, manganite, and wad. Braunite, which is reported to be a characteristic mineral in association with psilomelane in the Arkansas deposits, has not, so far as the writer is aware, been definitely identified, in the manganese deposits of the southeastern Atlantic states. In their principal occurrences two or more of these minerals are usually intimately associated, the most common being probably psilomelane and pyrolusite. The manganese-oxide mineral occurring in crystal form in these deposits has been regarded by some as pyrolusite, and by others as manganite. Both may be present, but their identification has been based almost without exception on a few physical

tests, rather than established by accurate chemical analysis, or a combination of the two.

The chief object of the present study is definitely to establish the mineral identity both of the crystals and crystalline mineral from the Virginia locality, and to direct attention by way of suggestion to the possible bearing on other occurrences.

Little Fort Valley in which the manganese deposits occur is structurally a synclinal valley composed of Silurian and Devonian sediments. At the Stockwood Realty Corporation's mine where the specimens forming the basis of this study were collected, the manganese oxide ore is associated with Oriskany conglomerate, the quartz pebbles of which range up to half an inch in diameter, and with a fine- to medium-grained sandstone just below, which probably is Salina but may prove upon detailed study to be Oriskany. These are brittle siliceous rocks that have been fractured and brecciated in the trough of the syncline where the manganese ore is concentrated. Most of the ore is apparently in the underlying light-colored sandstone, which is brecciated and replaced by manganese oxide. Where impregnation and replacement of the sandstone by manganese oxide have not reached an advanced stage, the ore is low grade and siliceous.

The sandstone is nearly white when fresh and not mineralized, composed almost entirely of quartz, and weathers to a light rusty brown. Microscopic examination of the mineralized rock shows, besides quartz and manganese oxide, an occasional zircon, and rather frequent hair-like inclusions of rutile. Much of the quartz exhibits pronounced optical disturbance and often granulation. Enlargement of the quartz grains was not observed.

Wad occurs, but most of the ore observed at the time of my visit was crystalline pyrolusite developed largely by replacement of quartz from circulating ground waters, but partly also as a breccia-filling or cement and partly as crusts coating joint surfaces and other spacings in the rocks.

Replacement of the rock by black manganese oxide (pyrolusite) is plainly shown in hand specimens. All stages of replacement are readily traced in thin sections under the microscope, from the incipient stage in which the quartz grains show only slight

attack, through advanced stages in which only a few or many scattered small fragments of residuary quartz remain, to the completed stage composed of all pyrolusite without visible quartz. The partly replaced, fine-grained rock of blue-black color is referred to locally as bluestone.

In this connection it is of interest to note that similar replacement of Cambrian quartzite by manganese oxide in the Virginia part of the Piedmont Plateau province is well shown in hand specimens and thin sections from the Myers manganese mine, east of Lynchburg in Campbell County. Also the formation of pyrolusite by replacement of quartzite in the Jubalpur district, Central Provinces, India, has been described in detail by Fermor.[1]

Pyrolusite crystals measuring more than a millimeter across are abundant at the Virginia locality in cavities and spacings in both the ore and the rock. They vary in habit from tabular to wedge-shaped, and frequently form closely interlocking aggregates on the surfaces of joint planes, coatings on crusts of crystalline fibrous or columnar pyrolusite, and linings of small irregular spacings in the blue-black ore; the latter appears amorphous to the unaided eye, but much of it is seen to be minutely crystalline granular under the magnifying lens.

Of the large number of specimens tested, of both the crystals and the crystalline mineral, all exhibited the physical and chemical properties of pyrolusite and none exhibited those of manganite. Although careful search was made and numerous tests applied, not a single specimen indicated the presence of manganite. Without exception the crystals tested were soft, not exceeding 2.5 in hardness, and readily soiled the fingers. Color, steel gray on fresh surfaces, black on other surfaces; luster, metallic; and streak, black to slightly bluish black. Careful determinations of the specific gravity gave 4.748 (crystals) and 4.885[2] (crystalline), values that correspond to those for pyrolusite and are much higher than that for manganite.

[1] FERMOR, L. LEIGH. Memoirs Geol. Survey India **37**: Pt. IV, pp. 811–814. 1909.

[2] Average of three determinations.

Chemically also the crystals and crystalline mineral correspond to pyrolusite, as shown in analyses of carefully selected samples of each given in columns I and II of table 1. There are given for comparison in columns III and IV analyses of pyrolusite crystals, and in column V "pseudomanganite"[3] from India.[4]

TABLE 1

ANALYSES OF PYROLUSITE CRYSTALS AND PSEUDOMANGANITE

	I	II	III	IV	V
MnO_2	94.30	95.22	96.73	97.04	92.90
MnO	2.25	1.31	0.57	0.43	1.47
Fe_2O_3	0.22	0.17	0.23	0.03	1.88[5]
Al_2O_3	0.14	0.18	0.18	0.17	
BaO	0.33	0.40		0.07	
CaO	0.08	0.11	0.66	0.90	0.86
MgO			0.76	0.47	0.52
SiO_2	0.64	0.63	0.42	0.41	0.47
P_2O_5	0.52	0.58			
H_2O-	0.22	0.16			
H_2O+	1.53	1.46	0.45[6]	0.35	1.94
	100.23	100.22	100.0	99.87	100.04
Specific gravity	4.748	4.885[7]		4.94	4.470

I. Pyrolusite crystals from Stockwood Realty Corporation's mine, 6 miles east of Woodstock, Shenandoah County, Virginia. S. D. Gooch, analyst.

II. Crystalline fibrous pyrolusite from Stockwood Realty Corporation's mine, 6 miles east of Woodstock, Shenandoah County, Virginia. S. D. Gooch, analyst.

[3] The name pseudomanganite was proposed by Fermor (Memoirs Geol. Survey, India **37**: Pt. I, p. 85. 1909) for pyrolusite pseudomorphous after manganite, that occupies both chemically and physically the interval between manganite and pyrolusite. The important physical properties of the three minerals are tabulated by Fermor on p. 86.

[4] For a description of the minerals and a discussion of the analyses, see Fermor (Memoirs Geol. Survey India **37**: Pt. I, pp. 78–86. 1909).

[5] Mostly Al_2O_3.

[6] By difference.

[7] Average of three determinations.

III. Pyrolusite crystals from Bikonhalli, Shimoga district, Mysore. C. S. Fawcitt, analyst. (Memoirs Geol. Survey India, Pt. I, p. 82. 1909.)

IV. Pyrolusite crystals (longish, dull, prismatic crystals of nearly square form) from Ghatia in Banswára State, Rijputána. C. S. Fawcitt, analyst. (Memoirs Geol. Survey India, Pt. I, p. 82. 1909.)

V. Pseudomanganite, bronzy luster, from Sandur Hills, India. C. S. Fawcitt, analyst. (Memoirs Geol. Survey India, Pt. I, p. 84. 1909.)

From the analyses it will be seen that the resemblance in composition of the crystals and crystalline mineral from Virginia is remarkably close, and the correspondence of each to the Indian pyrolusite is evident. The physical characters of each are alike and, as shown above, are those of pyrolusite. Each shows the presence of a small quantity of manganous oxide and about 1.5 per cent of combined water, which would usually be interpreted as the remnants left in the change of the mineral from manganite to pyrolusite, on the basis that the pyrolusite is pseudomorphous after manganite. The water, on the other hand, might be accounted for on the basis of hydration. Such alteration from manganite to pyrolusite has been generally regarded as easily accomplished and involves, chemically, dehydration and oxidation, accompanied by a change of physical characters, the more important of which are increased specific gravity, decreased hardness,[8] and darker (black) streak.

Judged from the few detailed chemical analyses of pyrolusite which the writer has examined, such small percentages of MnO and combined H_2O, when taken alone, are of little value as diagnostic features of the pseudomorphism of pyrolusite after manganite. (See statement on Indian pyrolusite below.) When combined, however, with accurate tests of physical properties, including crystal form, the evidence should be conclusive.

Attention is directed in the table to analyses III and IV of picked specimens of pyrolusite crystals described by Fermor

[8] Alteration to polianite, which has the same composition as pyrolusite and is sometimes pseudomorphous after manganite, would involve not only increased specific gravity but also increased hardness.

from India. No reference is made in the description by Fermor that the pyrolusite crystals represented by the two analyses are of pseudomorphous origin, but are tabulated by him as "Analyses of Indian pyrolusites," the present writer assuming that they are not pseudomorphous after manganite. Both analyses contain around 0.5 per cent each of manganous oxide and combined water, which are less than for pseudomanganite (analysis V) and for the Virginia pyrolusite (analyses I and II). In the same table Fermor gives a detailed analysis of "a piece of the radiate-concentric pyrolusite of Páli in the Nágpur district," which shows 0.41 per cent and 1.46 per cent respectively of MnO and combined H_2O, and specific gravity 4.88. Again the writer assumes this analysis to represent pyrolusite of nonpseudomorphous origin.

On comparing the analyses (I and II) of Virginia pyrolusite with the analysis (V) of pseudomanganite from India, it will be noted that the percentages of manganous oxide and combined water are in fairly close agreement. The same is true for the minor constituents, except that MgO present in pseudomanganite is absent from the Virginia pyrolusite; this, however, has no significance. Fermor[9] states that the pseudomanganite presents considerable differences in physical characters from pyrolusite but shows considerable resemblances to manganite, though chemically close to pyrolusite. The name pseudomanganite as proposed by Fermor is therefore not applicable to the Virginia mineral (pyrolusite crystals, analysis I, and crystalline pyrolusite, analysis II), since, as shown above, it resembles pyrolusite and not manganite both chemically and physically.

It seems entirely clear, on the basis of chemical composition and physical characters, that if the crystals of manganese oxide from Virginia (analysis I) are of pseudomorphous origin after manganite, the associated crystalline fibrous mineral (analysis II) must also be of the same origin. Certain of the facts developed in this study, especially the crystallography (abnormal axial ratio and habit for manganite) are, however, not in har-

[9] Fermor, L. Leigh. *Op. cit.*, p. 84.

mony with the view that the crystals and crystalline pyrolusite from Virginia are of pseudomorphous origin; these features may pertain to original pyrolusite. The writer is fully aware of the prevailing view that pyrolusite crystals are pseudomorphous in origin, and that many pyrolusite crystals have the form of manganite. The present study, however, of the material from the Virginia locality suggests the probability that the pyrolusite may be original; that is, it has a distinct crystalline form of its own, and is not secondary in the sense of being derived from manganite by dehydration and oxidation. More extended investigation of the manganese oxide minerals, especially pyrolusite and manganite, is under way by the writer, with the hope that more definite conclusions may be reached as to their genetic relations.

PART II. CRYSTALLOGRAPHY

The specimens examined contain irregular cavities a centimeter or two in diameter, lined with brilliant crystals corresponding in form to manganite,[10] averaging about a millimeter across. The habit varies from tabular, owing to the predominance of the front pinacoid or of prisms vicinal to it, to wedge-shaped, from the combination of prisms and side-domes. Subparallel intergrowth is frequent, causing variations of half a degree or so in the angles, so that comparatively few of the crystals can be used for measurement. The crystals are attached to the matrix in the general direction of the side pinacoid, and are doubly terminated as far as the vertical axis is concerned. The termination is of a type very unusual in manganite, being produced chiefly by side-dome faces, of which five prove to be new. Single faces of two possibly new pyramids, and of one previously noted pyramid, are also present, one on each of three crystals.

The development toward the attached end of axis *b* is very

[10] For the sake of simplicity the crystals will be called manganite, even though their physical and chemical properties are those of pyrolusite.

different from that at the free end,[11] although practically the same forms are present at both ends, the difference being in their relative sizes. The mineral is therefore probably not to be regarded as belonging to a hemihedral class, but to be pseudo-hemimorphic along the *b*-axis; the rate of accretion of material was of course greater at the free ends, and less where the crystals are crowded together, and this may account for the different development at the two ends. It may be noted that hemihedral (in part sphenoidal) arrangement of faces has been observed in manganite from many localities, so it is evidently a subtance that is especially sensitive to differences in rate of growth. This is probably to be explained by the presence in its space-lattice of some hemihedral features, which in the structure as a whole compensate each other and make the class holohedral, just as in diamond, which possesses a balanced tetrahedral arrangement of atoms and accordingly often simulates tetrahedral habit, although thought to be fundamentally holohedral.

Twelve crystals were measured on a Goldschmidt two-circle goniometer. Most of the faces present are more or less curved and striated, so that perfect reflections of the signal are rarely obtained. The unit prism sometimes yields excellent images, however, and one of the side domes fairly good ones. Variations in angle of half a degree or more occur from one crystal to another, even with the faces giving the best reflections, because of the subparallel intergrowth. In particular the wedge-shaped crystals tend to show a somewhat greater value for axis *a* than do the tabular ones. The measurements here accepted as characteristic of the occurrence are those obtained from small and apparently single tabular crystals with two or more faces yielding sharp images of the signal. The prism and dome zones generally show long trains of reflections, in which bright nodes indicate the positions of faces, and as these nodes reappear from one crystal to the next with considerable regularity, they undoubtedly represent actual forms.

[11] This habit has apparently not been noted in normal manganite heretofore, but appears in a diagram of pyrolusite given by Dana (System of Mineralogy, 6th ed., fig. 3, p. 244.)

The axial ratio derived from the measurements is clearly different from that usually accepted for manganite, but agrees almost exactly with that obtained by Flink on crystals from the Bölets Mine, Undenäs district, Sweden, $a:b:c = 0.8612:1:0.5629$.[12] From three closely agreeing measurements of the unit prism, its $\phi = 49° 15' \pm 5'$ whence $a = 0.8616 \pm 0.0025$; and from two of

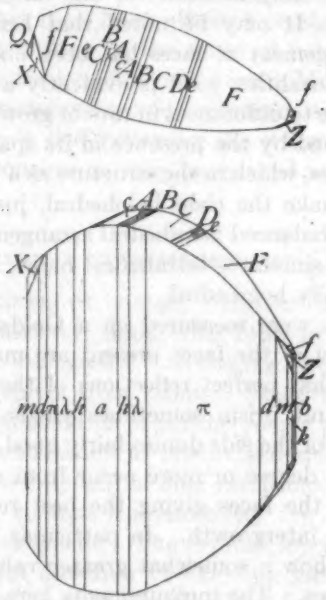

Fig. 1.

dome 032 its $\rho = 40° 10' \pm 5'$, whence $c = 0.5628 \pm 0.0020$. As Flink's crystals were probably better than the present ones. his values are used in calculating the angle-table. The difference between this axial ratio and that usually accepted for manganite, 0.8441 : 1 : 0.5448, is perhaps connected with the loss of hydrogen, corresponding to the change into pyrolusite, taking

[12] Arkiv Kemi Min. Geol. **3**: (35), 101. 1910. No analyses or physical properties of the mineral are given.

place chiefly in the direction of the *b*-axis, so that the greatest shrinkage occurs along this axis.[13]

Figure 1 presents the average development of crystals of this occurrence. Some crystals are even thinner than this, but on

TABLE 2

ANGLES OF PYROLUSITE AFTER MANGANITE FROM POWELLS FORT, VIRGINIA

$a:b:c = 0.8612:1:0.5629$

FORMS, SYMBOLS	DEVELOPMENT	TIMES NOTED		ANGLES							
				Measured				Calculated			
				ϕ		ρ		ϕ		ρ	
				Degrees	Min.	Degrees	Min.	Degrees	Min.	Degrees	Min.
c 001	Poor, irregular	5		0		0		0	00	0	00
b 010	Narrow, dull	8; cleav. 12		0		90		0	00	90	00
a 100	Part of curve	14		90		90		90	00	90	
		Plus	Minus								
h 410	Part of curve	2	2	78		90		77	51	90	00
λ 310	Part of curve	12	4	74		90		73	59	90	
π 520	Flattest part of curve	18	1	71		90		71	00	90	
d 210	Part of curve	10	1	67		90		66	42	90	
m 110	Narrow but bright	12	2	49	15	90		49	16	90	
k 230	Narrow but bright	2	0	37	40	90		37	45	90	
*A 018	Part of curve	2	1	0		4		0	00	4	02
*B 014	Part of curve	2	1	0		8		0		8	01
*C 013	Flat part of curve	20	1	0		10	30	0		10	38
*D 012	Part of curve	4	0	0		16		0		15	43
e 011	Part of curve	8	3	0		29		0		29	23
*F 032	Flattest part of curve	18	2	0		40	10	0		40	11
f 021	Part of curve	8	2	0		48		0		48	23
*Z 566	One curved face, doubtful	1	0	44		38		44	03	38	04
*X 654	One curved face, doubtful	0	1	54		50		54	20	50	21
p 111	May be represented by X and Z	0	0	—		—		49	16	40	47
Q 493	One curved face, obs. by Flink	0	1	27		62		27	18	62	15

[13] It is also possible that this axial ratio belongs to pyrolusite itself, and that the crystals are not pseudomorphs at all, as noted in Part I.

the other hand the wedge-shaped ones are thicker because of greater development of prism *d* or others near it. The height also varies somewhat, the thinner crystals tending to be longer in the *c* direction. The curvature of the faces which is almost universally present is indicated; it is actually the more prominent on the thicker, wedge-shaped crystals. Forms *b*, *m*, and *k* are narrow or lacking on some crystals, and each of the three pyramids has been observed but once, but the other forms, especially those at the right or positive end, are practically constant.

The domes fall excellently into harmonic series N_2, although the two vicinal to the base, 018 and 014, are extra.

Form.....	001	018	014	013	012	—	011	032	021	—	010
k											
l.....	0	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$	—	1	$\frac{3}{2}$	2	—	inf.
N_2.....	0	—	—	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1	$\frac{3}{2}$	2	3	inf.

A list of the forms and their angles is presented in table 2, new ones being marked by an asterisk. The formulas used for calculating ϕ and ρ are as follows:

$$\text{Prisms:}\quad \cot\phi = \frac{k}{h}\cdot a;\quad \text{domes:}\ \tan\rho = \frac{k}{l}\cdot c;$$

$$\text{Pyramids:}\ \cot\phi = \frac{n}{k}\cdot a;\quad \tan\rho = \frac{k\cdot c}{l\cos\phi}.$$

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

BOTANY.—*Axillary cleistogenes in some American grasses.* AGNES CHASE. Amer. Journ. Bot. **5**: 254–258, figs. 1–5. 1918.

All the species native in the United States of three genera of grasses, Triplasis, Danthonia, and Cottea, and two species from other genera, *Muhlenbergia microsperma* and *Pappophorum Wrightii*, are found to produce cleistogamous spikelets in the axils of the lower sheaths. These spikelets are enlarged, greatly simplified, usually 1-flowered, and without glumes, and often so strikingly different from the chasmogamous spikelets (that is those borne on the terminal panicle) of the same plant, that if their source were unknown they would not be placed in the same tribe. The grain of the cleistogene is usually more than twice as large as that of the chasmogene. Specimens bearing these cleistogenes usually disjoint at the nodes, the spikelet remaining permanently enclosed in the sheath and the grain germinating within it. In *Muhlenbergia microsperma* the cleistogenes are inclosed in indurate, greatly reduced leaf-sheaths, in shape like tiny inverted cornucopias. These are produced in abundance and readily fall from the expanded sheaths. Four South American and one New Zealand species of Danthonia and one Siberian and one Algerian species of Pappophorum are found to produce these cleistogenes. All species so far found producing them are plants of open ground, most of them are of arid regions or in dry places in humid regions. Since with relatively little investigation so many species have been found with cleistogenes it seems probable that this is not a rare habit in grasses. Any grass with swollen sheath-bases and disjointing culms may repay examination, after the maturity of the terminal panicles. A. C.

BOTANY.—*Generic types with special reference to the grasses of the United States.* A. S. HITCHCOCK. Amer. Journ. Bot. **5**: 248–253. 1918.

Stability in nomenclature has been aided by the adoption of the idea of types, a genus being based upon a type species and a species upon a type specimen. In the present paper the author summarizes a study that he has made in applying the principle of types to 255 generic names of grasses. In 8 genera the type species has been designated. Of those in which no type was designated at the time of publication, 150 were based upon single species. In the remaining cases types have been selected on the principle that the type must be one of the species included in the genus as originally published and should be the species or one of the species that the author had chiefly in mind at that time. The difficulties are greatest in the Linnaean genera. Several examples are given illustrating the methods used in the selection of the type species. A. S. H.

PHYTOPATHOLOGY.—*The growth of the potato-scab organism at various hydrogen-ion concentrations as related to the comparative freedom of acid soils from the potato scab.* L. J. GILLESPIE. Phytopathology **8**: 257–269. 1918.

A study was made of the viability of a number of strains of the common potato-scab organism in culture media adjusted to various hydrogen-ion exponents. Two synthetic media and a medium prepared from potato extract were used, and especial attention was paid to the buffer action of the culture media. In media at the initial exponent 5.2 the growth was slower and generally less vigorous than at less acid exponents. Under some conditions individual strains were somewhat more sensitive to acidity, but the differences did not lead to any consistent distinctions among the strains. Sometimes the organisms succeeded in growing well in a medium which had initially an exponent of 5.2 or even 4.8, but the growth was accompanied by a marked decrease of acidity, and the manner of growth gave reason to doubt whether even in these cases more than a poor growth can occur at such exponents.

It would appear that the acidity of the Caribou loam, which is known to be generally immune from the common (corky) potato scab, is often of sufficient intensity to exert in the soil an injurious action on the causal organism. The acidity of the Washburn loam, on the

other hand, is generally not of sufficient intensity to be injurious to the causal organism, and potatoes grown on the Washburn loam are very often infected with the common scab. L. J. G.

PHYTOPATHOLOGY.—*Irrigation experiments on apple-spot diseases.* CHARLES BROOKS and D. F. FISHER. Journ. Agr. Res. **12**: 109–138, pls. 2–5, figs. 1–10, tables 1–11. January 21, 1918.

The writers point out the distinguishing characteristics of a number of different spot diseases of the apple, including bitter pit, Jonathan spot, and drouth spots of various kinds, but the paper is devoted mainly to experimental data on the relation of the soil-water supply to the occurrence of these various troubles. In the experimental work the amount of soil water was controlled by the duration and frequency of irrigation and was determined from soil samples taken at various depths. Bitter pit was found to be greatly increased by heavy irrigation, particularly when applied late in the season. It was decreased by heavy irrigation followed by light. It was in general worse on large apples than on small ones, but heavy irrigation caused practically as great increase of the disease on small and medium sized fruit as on the large. Drouth spot were found to be produced by sudden shortage of water. Certain kinds of drouth and cork were apparently correlated with particular soil types. C. B.

PHYTOPATHOLOGY.—*A leafblight of* Kalmia latifolia. ELLA M. A. ENLOWS. Journ. Agr. Res. **13**: 3. April 15, 1918.

The disease was found on mountain laurel in the vicinity of Washington. It is characterized by a blight or dry rot involving large areas of the leaf blade or the entire leaf. Later it extends through the petioles into the stems and may eventually kill the entire plant. The causal fungus is a new species: *Phomopsis kalmiae*, its parasitism having been demonstrated by successful inoculations into healthy plants.

Pycnidia are readily produced on diseased leaves placed in damp chambers. Sclerotia-like bodies and pycnidia are produced in large numbers in most of the ordinary culture media. The sterile bodies are undoubtedly potential pycnidia as shown by the production of pycnospores after transplanting portions to fresh culture media.

E. M. A. E.

PHYTOPATHOLOGY.—*Host relationships of the North American rusts, other than Gymnosporangiums, which attack conifers.* ARTHUR S. RHOADS, GEORGE G. HEDGCOCK, ELLSWORTH BETHEL, and CARL HARTLEY. Phytopathology **8**: 309–352. July, 1918.

This paper, which is of special interest to forest pathologists and mycologists, treats of fifty-two species of rusts attacking species of Abies, Ephedra, Larix, Picea, Pinus, Pseudotsuga, and Tsuga. With each species of rust is an abbreviated synonomy; citations of publications containing treatment of the species; a list of the coniferous host species; the names of genera bearing alternating stages, when present, of each rust; the distribution; remarks relative to important characters; and data of inoculating proof of the connection between the aecial and telial stages.

At the close of the paper is a host index in two parts, one of aecial hosts, the other of uredinial and telial hosts; and 148 citations of literature bearing upon the subject. G. G. H.

PHYTOPATHOLOGY.—*Some bacterial diseases of lettuce.* NELLIE A. BROWN. Journ. Agr. Res. **13**: 367–388, pls. 29–41. May 13, 1918.

The paper describes two new bacterial diseases of lettuce, one occurring in South Carolina and Virginia on lettuce grown out of doors, the other on greenhouse plants in Kansas. The organism producing the disease in South Carolina and Virginia has been named *Bacterium vitians*. In South Carolina, *Bacterium vitians* causes the lettuce stems to turn blue, then brown when seen in cross or longitudinal sections. Leaves are spotted occasionally but the stem affection is the prevalent condition. The organism isolated from diseased stems of South Carolina plants produces spots on leaves as well as brown stems when inoculated into healthy lettuce plants.

In Virginia the leaf spotting only was noted, but the isolated organism from these leaf spots will produce stem-rot readily when inoculated into the stem of healthy lettuce plants, as well as spots on leaves when it is sprayed on the leaves of healthy lettuce. The diseased Virginia lettuce had a second organism present producing spots on it, and this organism was isolated along with *Bacterium vitians*. It is one already known and described (*Bacterium viridilividum*) and the colonies isolated proved to be infectious.

It appears that *Bacterium vitians* and *Bacterium viridilividum* may be present and active in soil which is heavily fertilized with green

manure or stable manure not thoroughly decomposed, and in which the organisms of decomposition are still active. If conditions are such that the plants are kept growing vigorously, these organisms will have no effect upon them, but if bad weather conditions obtain and the lettuce plants get weakened or growth is retarded, these organisms make their way into the roots or leaves and cause disease. The treatment recommended is the use of thoroughly decomposed green manure and well-seasoned stable manure in which tissue-disintegrating bacteria are inactive.

The Kansas disease is caused by a soil organism, to which the name *Bacterium marginale* has been given. It produces either a marginal wilting, or a spotting and speckling of the leaves. Care in watering plants so that soil does not get washed on the leaves and proper ventilation of greenhouses will prevent the disease.

Isolations, inoculations, cultural characteristics, and descriptions of the two organisms are discussed. N. A. B.

PHYTOPATHOLOGY.—*Influence of temperature and precipitation on the blackleg of the potato.* J. ROSENBAUM and G. B. RAMSEY. Journ. Agr. Res. **13**: 507–513, fig. 1, tab. 3. June 3, 1918.

Experiments were performed which showed that the organism (*Bacillus phytophthorus* Appel) producing the blackleg disease of the potato, under the winter conditions that existed during 1915–1916 and 1916–1917 in Aroostook County, Me., cannot live over in the soil or in diseased tubers that may remain there.

Comparison of weather records show that the winter of 1915–1916 was not an unusual one for Aroostook County.

The severity of the disease during the growing season is closely correlated with temperature and precipitation. A high temperature and low precipitation tend to diminish the disease, while a low temperature and high precipitation produce conditions favorable for it. J. R.

PHYTOPATHOLOGY.—*A hitherto unreported disease of okra.* L. L. HARTER. Journ. Agr. Res. **14**: 207–211, pl. 23, figs. 3. July 29, 1918.

The author investigated a disease of the pods and stems of okra which occurred in Maryland in 1916. Infection experiments showed that several different varieties of okra were susceptible. The causal fungus was described as a new species of Ascochyta, *A. abelmoschi*.

L. L. H.

TECHNOLOGY.—*Combined table of sizes in the principal wire gages.* Bur. Stand. Cir. No. 67. Pp. 5. Jan. 17, 1918.

This table combines in one series the sizes in the American (B. & S.) Steel, Birmingham (Stubs'), British Standard, and Metric Wire Gages, arranged in order of sizes (diameters) of wires. It gives the diameter of all the gage numbers in these five systems in mils, millimeters, and inches, also the cross-sections in square mils, circular mils, square millimeters, and square inches. The table is especially useful to manufacturers who wish to determine the nearest equivalent in American or British gage sizes of wires specified in millimeters or square millimeters, or vice versa. R. Y. F.

TECHNOLOGY.—*Determination of permeability of balloon fabrics.* JUNIUS DAVID EDWARDS. Bur. Stand. Tech. Paper No. 113. Pp. 31. 1918.

This paper describes the various methods which may be employed for determining the permeability of balloon fabrics to hydrogen. The precise and rapid method used at the Bureau of Standards measures the hydrogen penetrating a given area of fabric by means of a gas interferometer. Data are given to show the effect upon the apparent permeability of different experimental conditions such as temperature, pressure, humidity of the gas, etc. A knowledge of the effect of these factors enables one to compare results of tests made under different conditions. The test adopted as standard by the Bureau is described. J. D. E.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

The Board of Managers met on September 2, 1918. Mr. WILLIAM BOWIE resigned as treasurer, on account of having been commissioned a major in the Engineering Corps, U. S. A., and Mr. R. L. FARIS, of the Coast and Geodetic Survey, was elected treasurer for the remainder of the year. A committee consisting of C. N. FENNER, C. N. COLLINS, and J. A. FLEMING was appointed to audit the accounts of the retiring treasurer. Mr. E. W. SHAW was appointed chairman of the Committee on Meetings, succeeding Dr. SWANN, who has left the city, and Dr. C. W. KANOLT was made an additional member of the Committee.

The following persons have become members of the ACADEMY since the last issue of the JOURNAL: Dr. WILLIAM CLINTON ALDEN, U. S. Geological Survey, Washington, D. C.; Mr. SAMUEL SANFORD, Bureau of Mines, Washington, D. C.

ROBERT B. SOSMAN,
Corresponding Secretary.

SCIENTIFIC NOTES AND NEWS

A party of scientists has been sent by the Bureau of Plant Industry, at the request of the French High Commission, to Algeria, Tunis, and Morocco to study and advise upon agricultural conditions there. The party includes E. C. CHILCOTT, C. S. SCOFIELD, and T. H. KEARNEY.

Dr. ARTHUR L. DAY has presented his resignation as director of the Geophysical Laboratory, Carnegie Institution of Washington, to be in effect October 1, 1918, and will take up research on glass and allied materials for the Corning Glass Works in Corning, New York. Dr. DAY has been director of the Laboratory since its establishment in 1906, having been previously engaged in silicate researches at the U. S. Geological Survey in 1904 and 1905.

Mr. F. A. MCDERMOTT, formerly research chemist with the Corby Company, is at the experiment station of E. I. du Pont de Nemours and Company, at Henry Clay, Delaware.

Dr. H. C. MCNEIL, of the chemical department of the Bureau of Standards, has been appointed professor of chemistry at George Washington University, as successor to Prof. C. E. MUNROE, who is giving all his time to the work of the Committee on Explosives Investigations of the National Research Council.

Prof. F. A. SAUNDERS, professor of physics at Vassar College, Poughkeepsie, N. Y., is in Washington on leave of absence, engaged in war work at the National Research Council.

Dr. E. C. SHOREY, in charge of the division of chemical investigations of the Bureau of Soils, Department of Agriculture, has resigned to accept a position with the National Aniline and Chemical Company, at Marcus Hook, Pennsylvania.

Prof. W. J. SPILLMAN, chief of the Office of Farm Management of the Department of Agriculture, resigned on August 31, 1918, to become editor of the *Farm Journal*. He will continue to reside in Washington for the present.

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